

## TITLE OF INVENTION

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Title: MANUALLY ACTUATED POSITIONING DEVICE WITH HIGH RESOLUTION AND  
LARGE RANGE OF MOTION

## CROSS-REFERENCE TO RELATED APPLICATIONS

Provisional Patent Application #: 60/434,301

## STATEMENT REGARDING FEDERALY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

## REFERENCE TO SEQUENCE LISTING, A TABLE, OR A COMPUTER PROGRAM

LISTING COMPACT DISK APPENDIX

Not Applicable

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to (i) positioning devices and more particularly to manually actuated linear stages; and to (ii) anti-backlash screw-nut assembly mechanisms generally used in positioning devices.

### 2. Description of the Relevant Art

In a linear stage two plates slide parallel and opposite to one another. If a screw and nut assembly connects the two plates of said linear stage, the rotation of the screw generates a rectilinear motion. There is always a tradeoff between the resolution and the total travel of a linear stage, particularly when it is manually operated. For instance, for a screw with a thread pitch of 0.050 inches (1.27 mm), as in a ¼"-20 ACME thread lead-screw, a 5 degree rotation translates into a linear motion of approximately 0.0007 inches (0.0176 mm or 17.6 microns). Using the same lead-screw, it takes 200 full turns or revolutions to move the stage 10 inches (254 mm). This is inconvenient when high resolution and fast motion are

required in manually operated single or multi axis positioning devices. However, this limitation can be overcome by temporally disconnecting the threads of the nut and the screw, leaving the linear stage free to be rapidly positioned, and then, re-connecting the threads of the nut and the screw to resume the linear stage high resolution motion.

## SUMMARY OF THE INVENTION

The present invention relates to a linear stage having a screw-nut assembly which comprises a nut-housing, a nut and a screw. The nut is connected to one plate of the stage through the nut-housing. The internal thread of the nut mates with the external thread of the screw, which is attached to the other plate of the stage. In this configuration, a rotation of the screw results in a rectilinear motion, and said motion has a resolution given by the thread pitch of the screw and the nut, and a travel limited by the length of the screw. The nut in the screw-nut assembly has a partial thread and a contiguous round excision; and said nut is held in the nut-housing so it pivots perpendicular to the axis of the screw. In addition, said nut is radial and axial preloaded with respect to the screw, to eliminate backlash.

The internal thread of the nut and the external thread of the screw are disconnected by manually overcoming the radial preload on the nut, and the stage can be rapidly repositioned by the operator. By releasing the nut, the screw and nut threads connect and the stage can then be moved by turning the screw.

A plurality of linear stages concatenated with one another to form a multi-axis positioning device. Said multi-axis positioning device having linear stages with angle adjustable bases, micrometer resolution and rapid displacement via a quick disconnect nut mechanism as described in the present invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

**FIG. 1** is a top view, side view and bottom view of a linear stage with a quick-disconnect, anti-backlash screw-nut assembly as described in the present invention.

**FIG. 2** is a side sectional view of the screw-nut assembly shown in **FIG. 1**, depicting the pivoting point and radial preload on the nut, which enables the connection between the inner thread of the nut and the outer thread of the screw.

**FIG. 3** is a side sectional view of the screw-nut assembly when a force opposite to the radial preload is applied, which disconnects the inner thread of the nut and the outer thread of the screw.

**FIG. 4** is a top sectional view of the screw-nut assembly shown in **FIG. 1**, to depict the axial preload on the nut.

**Fig. 5** is a view of a multi-axis positioning device, composed of a plurality of linear stages as described in the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a linear stage having an anti-backlash screw-nut assembly which comprises a nut-housing **30**, a nut **40** and a screw **50**. The nut is connected to one plate **10** of the stage through the nut-housing **30**. The internal thread of the nut **40** mates with the external thread of the screw **50**, which is attached to the other plate of the stage **20**. In this configuration, a rotation of the screw results in a rectilinear motion. In the case of the linear stage shown in **FIG. 1**, this is achieved by manually turning the knob **60**, which is connected to the screw **50**.

As shown in **FIGS. 2-4**, the nut **40** is held in the nut-housing **30**, such as said nut **40** pivots **43** perpendicular to the axis of the screw **50**; and said nut **40** having an internal thread and a contiguous round excision, resulting in the partial removal of the internal thread **41**. Said nut **40** having the center point of the imaginary circumference projected by its partial internal thread in the same geometric plane than the pivoting point. In addition, by inserting compression springs between said nut **40** and nut-housing **30**, said nut is radial **45** and axial **46** preloaded with respect to the screw **50**. The radial **45** preload allows the connection of the inner thread of the nut **40** and the outer thread of the screw **50**. Also, the radial **45** preload on said nut **40** compensates for the non-linearity and out of roundness of the screw **50** and eliminates all possible play between the internal thread of the nut and the external thread of the screw. In addition, the axial **46** preload on said nut **40** eliminates all possible play between the nut and the nut housing. If said nut **40** is fitted in the nut-housing **30** such as there is no permissible axial play, but the pivoting motion of said nut **40** is still allowed, only radial preloading **45** of said nut is required to connect the nut **40** and the screw **50** and to eliminate backlash.

The internal thread of the nut **40** and the external thread of the screw **50** are disconnected by overcoming the radial **45** preload on the nut **40** (see **49** in **FIGS. 2-3**). Given that the cutout adjacent to the partial thread of said nut **40** is made bigger than the diameter of the screw, said nut **40** is free to move along the axis of the screw (see **41 FIG. 3**), and the stage can be rapidly repositioned by the operator. By releasing said nut **40**, the screw and nut threads connect and the stage linear motion is then resumed by turning the knob **60** connected to the screw **50**.

**FIG. 5** shows a plurality of linear stages **70, 80, 90** concatenated with one another to form a multi-axis positioning device. Said multi-axis positioning device having linear stages with angle adjustable bases **90**, micrometer resolution and rapid displacement via a quick disconnect anti-backlash nut mechanism as described in the present invention.

For simplicity, the description of the invention is limited to a rectilinear motion. However, the invention is extended to any translational movement along the screw which is generated by the rotation of the screw relative to a moving part coupled to said screw via a nut. Said screw rotation being manual or motor driven. Also, the invention is extended to full thread nuts, in which radial and axial preloading in addition to pivoting, are used to effectively eliminate backlash.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those knowledgeable in the art that several changes in form and details may be made therein without departing from the scope of the invention.